Clean Cities Webinar

# NGVs Past & Prologue

## Lessons Learned to Create Deployment Strategies for Commercializing NGVs:

## Global Overview of Markets & Poli-techs (standards & regulations)

presented by


Dr. Jeffrey Seisler

Clean Fuels Consulting


6 October 2014

Clean Cities U.S. Department of Energy

# Acknowledgements

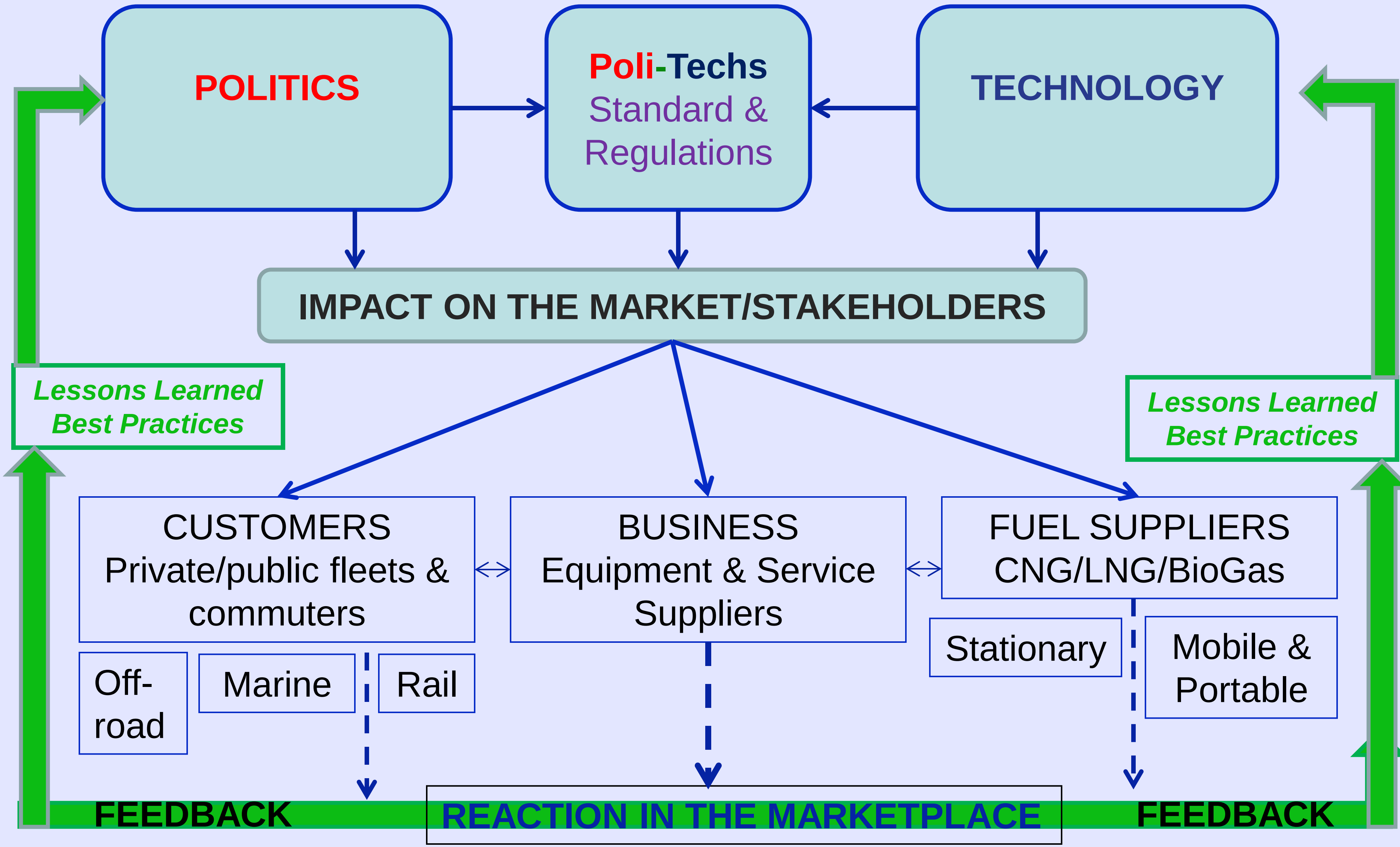

- Thanks for the DOE for their support:
  - Clean Cities
  - International DOE
- Thanks to Marcy Rood-Werpy & Dan Santini for their personal support and enthusiasm for this work
- Special thanks to Dan Santini for his rigorous, dedicated and intellectually challenging involvement in refining this presentation.


Clean Cities
U.S. Department of Energy



Clean Fuels CONSULTING

# Structure & Dynamics Framework for this presentation



# Overview of the Webinars

## Webinar 1: 6 Oct 2014

- **Background to success in NGV markets**
  - ***NGVs by the numbers: Looking Back-Looking Forward***
- **Poli-techs: NGV Standards and Regulations**

## Webinar 2: Week of 17 November 2014

- **NGV Technology, Best Strategies & Lessons Learned**

## Webinar 3: 15 December 2014

- **Role of Government: *Policy making & Strategy Process***
- **Infrastructure Concepts & Strategies**
- **Best Strategies: Institutional Lessons Learned**

# FACTORS REQUIRED FOR NGV SUCCESS

- Favorable economics
  - Cost differential between natural gas & petroleum;
  - Price differential of an NGV vs petrol/diesel vehicle
- Energy industry support
  - Gas industry vs. Oil/Gas industry
- Availability of vehicles (*real*, & not *implied* support of manufacturers)
- Government commitment
- Environmental policies driving lower emissions

Clean Cities
U.S. Department of Energy



Clean Fuels CONSULTING

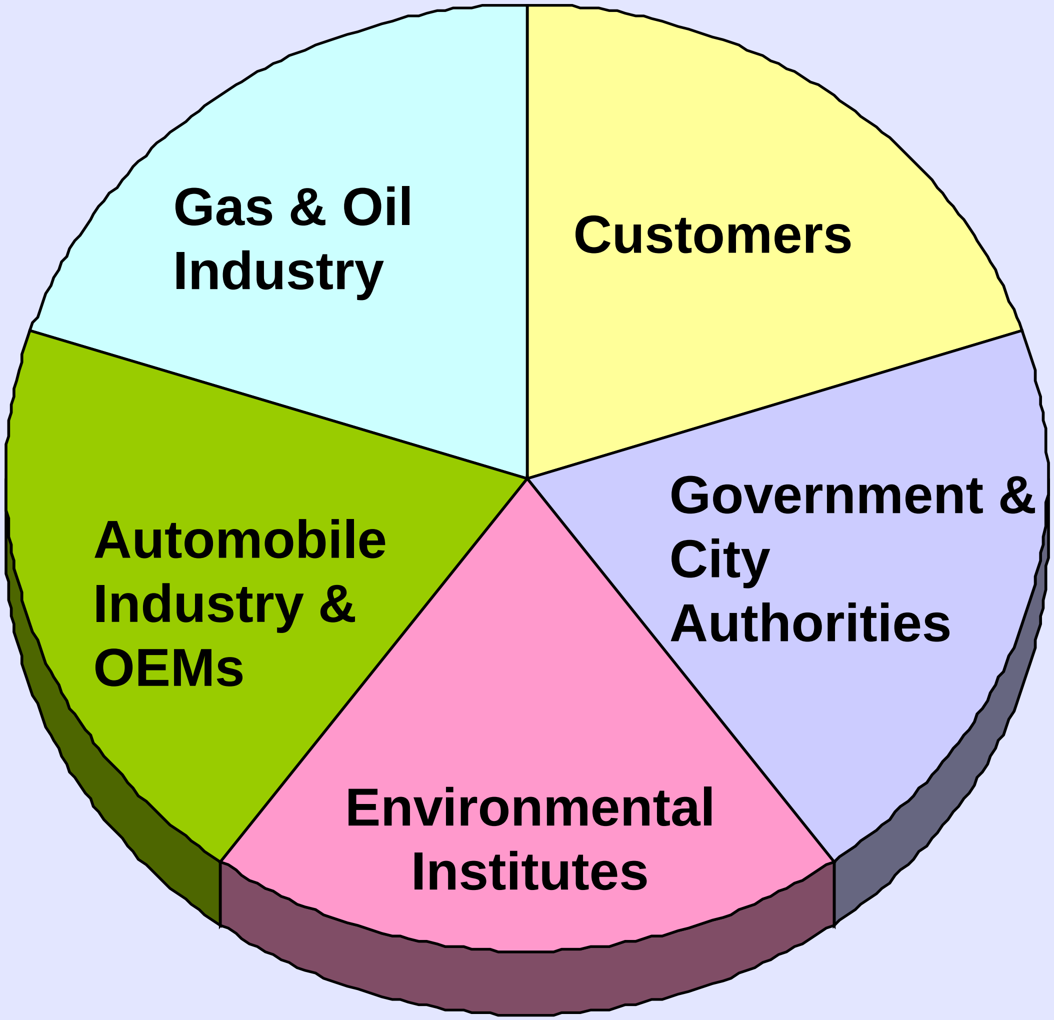
# New Fuel Reality Check

- Transition to new fuel(s) can affect our ability to compete in the world market.
- While it is tempting to make quick decisions, analysis is needed to make the *best* decisions.
- Technology breakthroughs and major world events may cause reevaluations.
- Transition will take years to complete.
- Even a wildly successful new fuel will coexist with gasoline and diesel for decades while older vehicles are phased out.

Source: *Checklist for Transition to New Highway Fuel(s)*, Charles Risch, Danilo Santini, January 2012.

# THE CRITICAL "NGV" STAKEHOLDERS EACH ONE HAS A ROLE TO PLAY

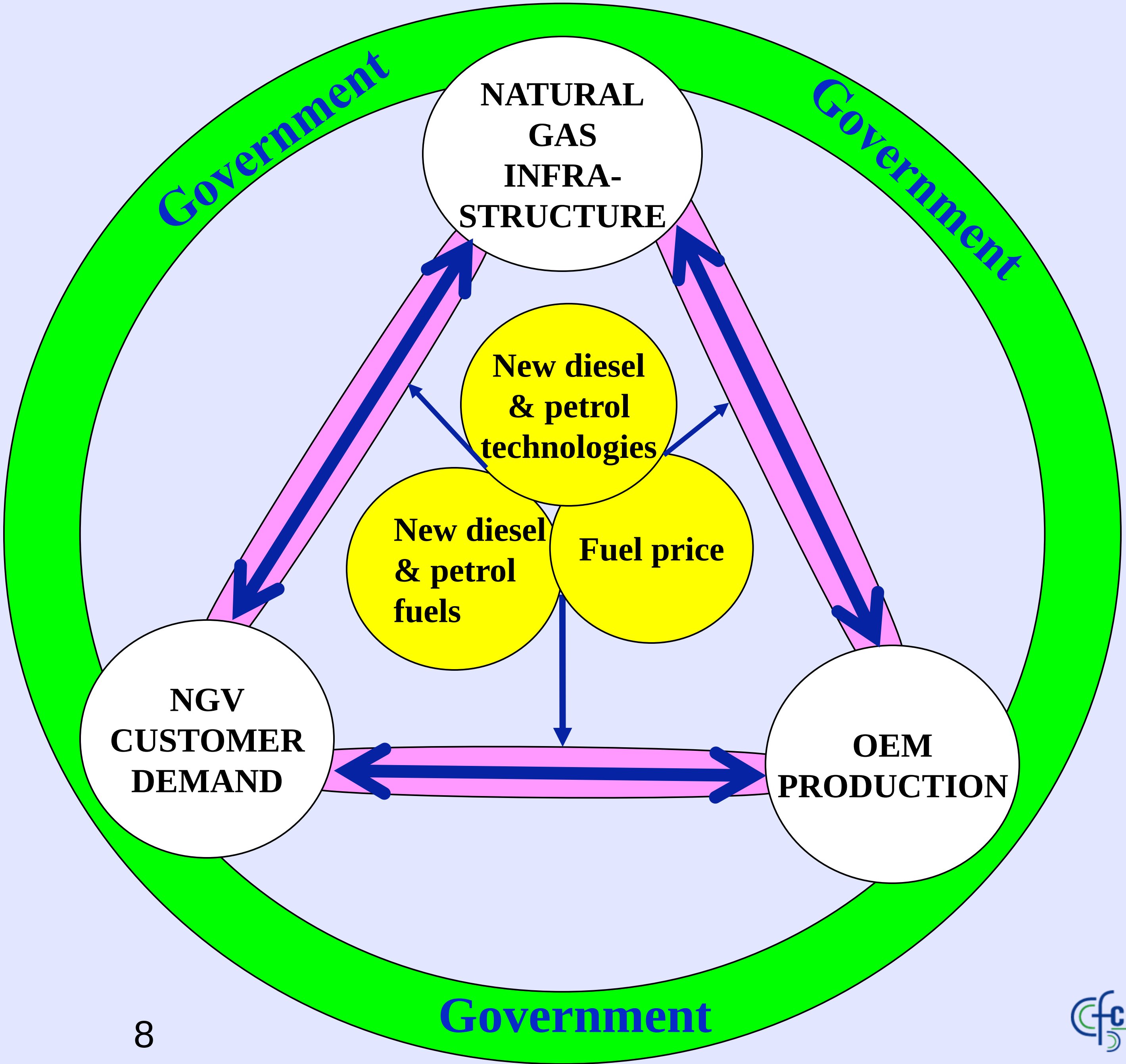
## (but the must be *motivated* to play!)




Clean Cities
U.S. Department of Energy

Clean Fuels CONSULTING

# Balance of NGV Commercialization



# NGV success for customers is based on economics

- **Fuel Cost**
- *Typically natural gas is 30-50% cheaper than gasoline and diesel (also depends on taxes)*
- *Fuel price savings offsets higher first cost of vehicle*
- **Vehicle Cost**
- *All alternative fuel vehicles (AFVs) cost more than gasoline/diesel (unless subsidized by the manufacturer)*
- *NG cars typically are $2000-$5000 or more than gasoline vehicles*
- *Conversions are less depending on market: $800+*
- *Trucks and buses can be $30,000-70,000+*

Clean Cities U.S. Department of Energy

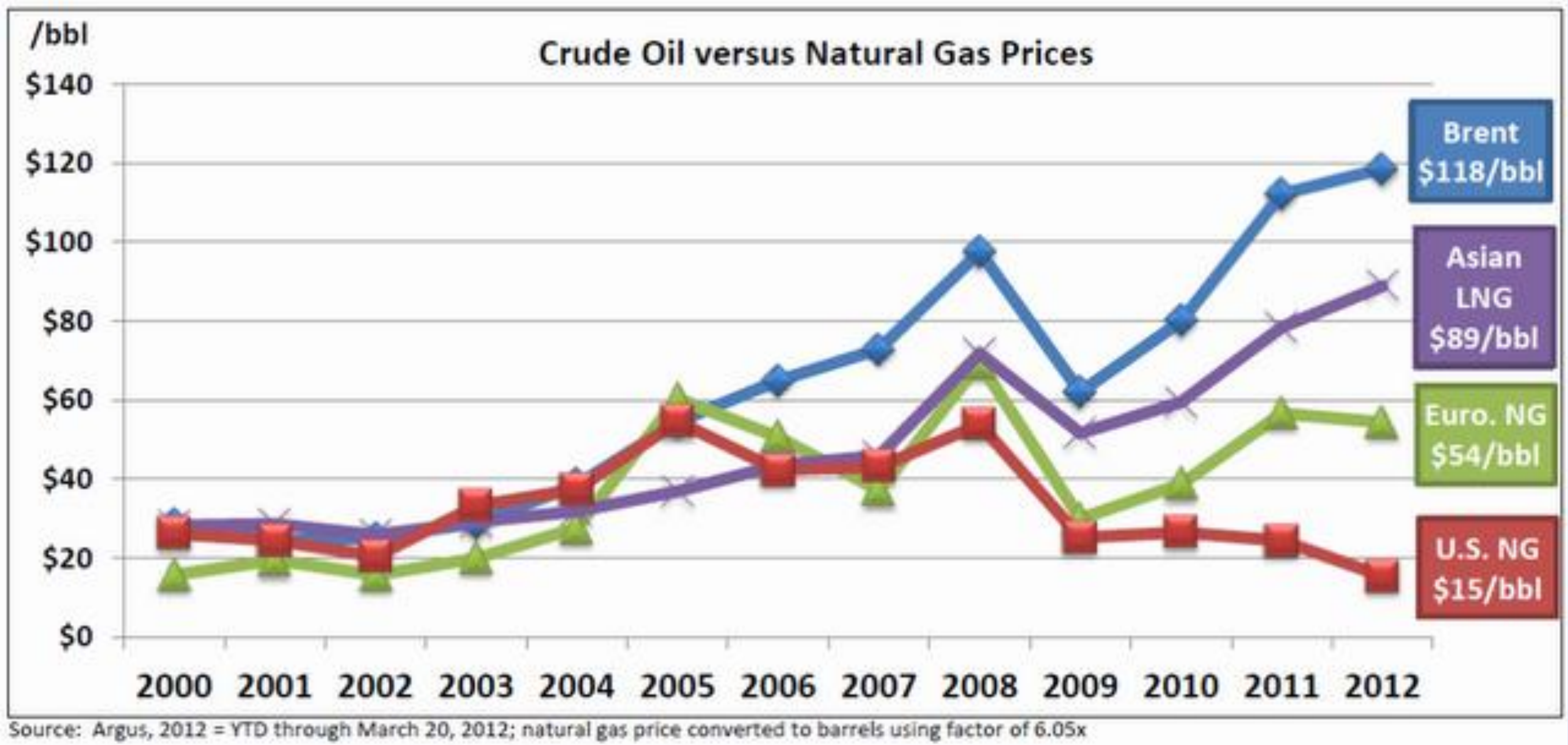


Clean Fuels CONSULTING

# PRICE OF CRUDE OIL & NATURAL GAS

## Natural gas typically tracks below oil but since 2009 the price is 'decoupling'

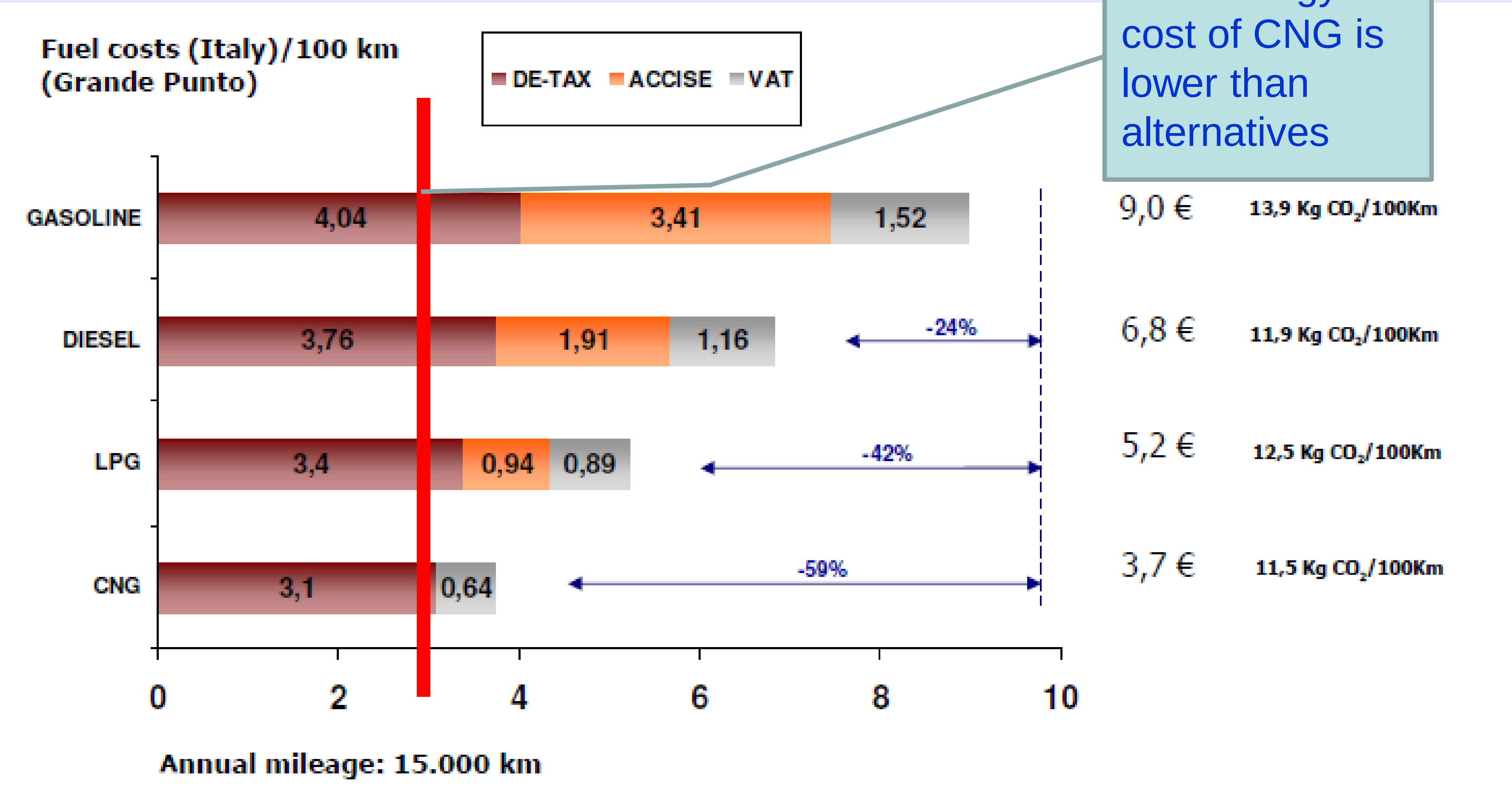
## *(to the benefit of natural gas!)*




Barrel of oil equivalent (bbl)

# Ultimately it is the NGV running costs that make the difference…and natural gas generally is cheapest! BUT…fuel tax policies play an important role! (Italian example)

The energy cost of CNG is lower than alternatives




Adapted from M.Ziosi, Prospects fior the Development and Use of CNG in Transport: Italy, (Promoting the Uptake of Gaseous Vehicle Fuels, Biogas and Natural Gas, in Europe GasHighWay,)1.2.2010

# NGVs by the numbers: Looking Back-Looking Forward


Source: ENGVA Conference theme/logo, Graz, Austria 2004

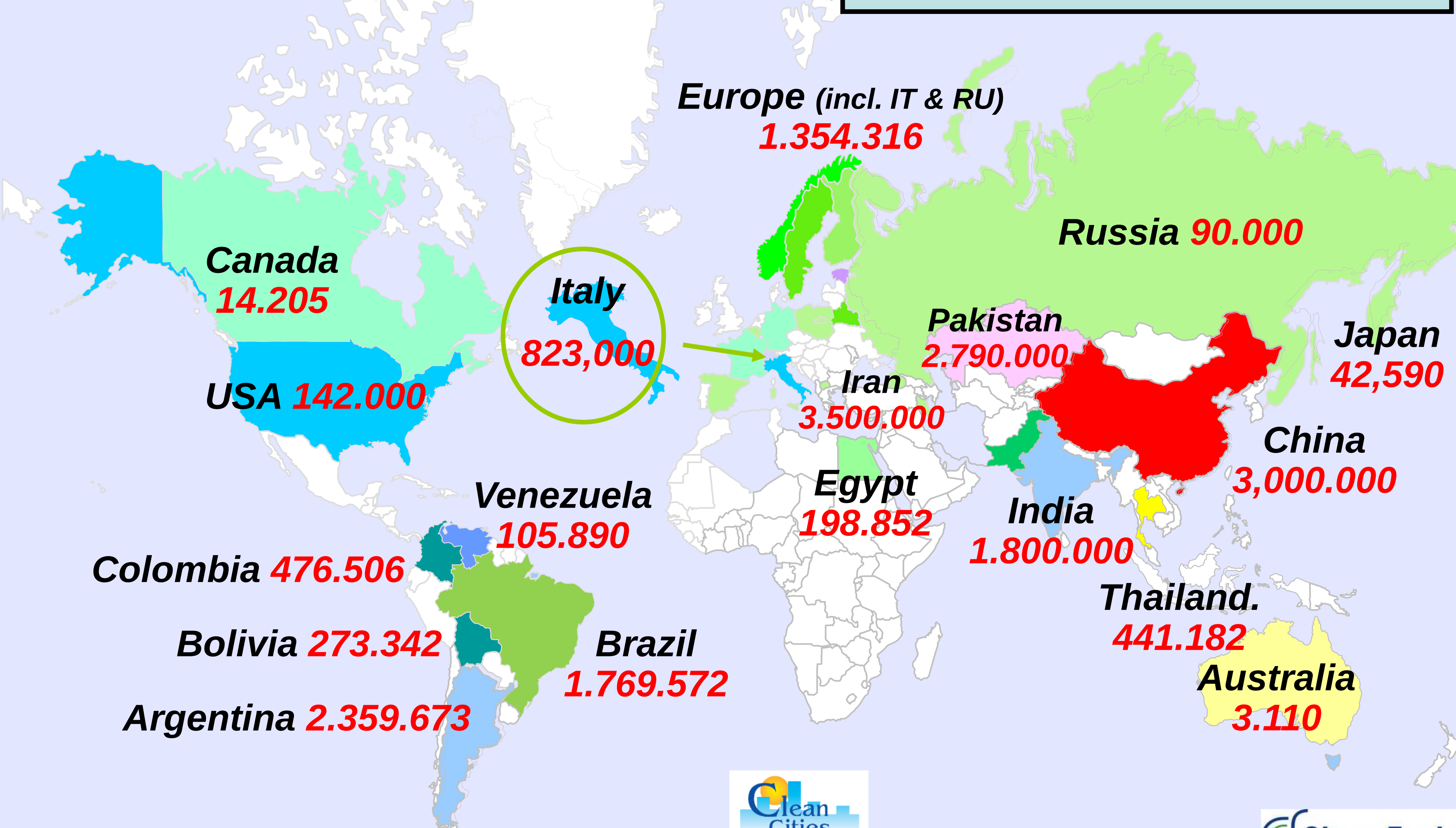
# NGVs IN THE WORLD

# 2014

**World Total**

~ 19,6 M | 25.135 | 1.343

NGVs | Fuelling Stations (FS) | FS Under construction




Data source: The GVR & ASIAN NGV, April 2014

# The top 10 NGV countries in the world based on total NGVs

## (with % price differential to petrol)

| | Total NGVs | Fuelling stations | % Price CNG less than Petrol |
|---|---|---|---|
| Iran | 3.500.000 | 1.904 | 75 |
| China | 3.000.000 | 5.730 | 50 |
| Pakistan | 2.790.000 | 2.997 | 65 |
| Argentina | 2.359.673 | 1.932 | 71 |
| Brazil | 1.769.572 | 1.805 | 47 |
| India | 1.800.000 | 903 | 47 |
| Italy | 823.000 | 1.022 | 62 |
| Colombia | 476.506 | 703 | 47 |
| Uzbekistan | 450.000 | 213 | 74 |
| Thailand | 441.182 | 491 | 75 |

•US$/Liter vs 1 Nm3 gas

**Data source: The GVR, April 2014**

# The top 10 NGV countries in the world & vehicles per station

| | Total NGVs | Fuelling stations | Vehicles per fuelling station |
|---|---|---|---|
| Iran | 3.500.000 | 1.904 | 1.838 |
| China | 3.000.000 | 5.730 | 524 |
| Pakistan | 2.790.000 | 2.997 | 931 |
| Argentina | 2.359.673 | 1.932 | 1.221 |
| Brazil | 1.769.572 | 1.805 | 980 |
| India | 1.800.000 | 903 | 1.993 |
| Italy | 823.000 | 1.022 | 805 |
| Colombia | 476.506 | 703 | 678 |
| Uzbekistan | 450.000 | 213 | 2.113 |
| Thailand | 441.182 | 491 | 899 |

Data source: The GVR, April 2014

# Vehicles per fuelling station

(600-1000 vehicles per station economically is optimal)

## April 2014

**Europe Total NGVs**

**~ 1.354.316**

**Refuelling Stations**

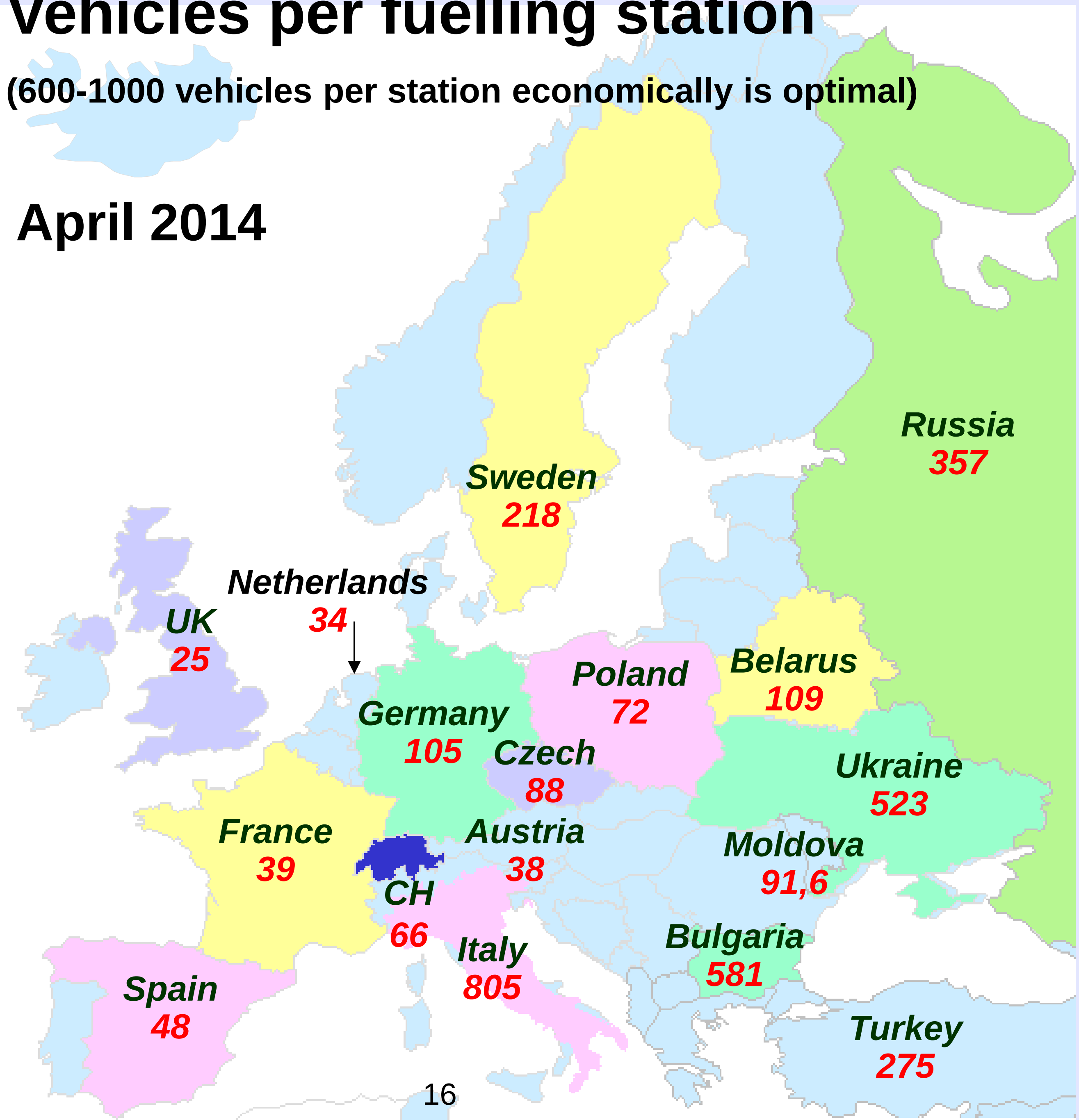
**~4.108**

**Stations Under Construction**

**292**

* Rounded up figures

Data source: The GVR, April 2014




Ratio in EUROPE

# Top Ten NGV Countries in the World
# % NGVs of *All* Vehicles

| | Total NGVs | Total vehicle population[1] | % NGVs of All Vehicles |
|---|---|---|---|
| Iran | 3.500.000 | 11.900.000 | 3 |
| China | 3.000.000 | 109.220.000 | 3 |
| Pakistan* | 2.790.000 | 2.636.000 | 106 |
| Argentina | 2.359.673 | 11.473.000 | 21 |
| Brazil | 1.769.572 | 37.271.000 | 5 |
| India | 1.800.000 | 22.622.000 | 8 |
| Italy | 823.000 | 42.000.000 | 2 |
| Colombia | 476.506 | 3.812.000 | 13 |
| Uzbekistan | 450.000 | 1.634.600** | 28 |
| Thailand | 441.182 | 12.749.000 | 4 |



**Data source: The GVR, April 2014**

*A vast majority of vehicles are Tuk-Tuks not autos. Auto population numbers subject to availability and *very* wide variation

** 2010 data

[1]International Assoc Automobile Constructers (OICA), 2013 (2012 data)

# Top ten NGV countries in the world by vehicles per capita

| | Total human population* | NGVs | NGVs per 1000 people |
|---|---|---|---|
| Armenia | 3.017.400 | 244.000 | 80,86 |
| Argentina | 42.669.500 | 2.359.673 | 55,30 |
| Iran | 77.381.000 | 3.500.000 | 45,23 |
| Bolivia | 10.027.254 | 273.342 | 27,25 |
| Georgia | 4.483.800 | 80.600 | 17,97 |
| Pakistan | 186.262.000 | 2.790.000 | 14,97 |
| Uzbekistan | 30.183.400 | 450.000 | 14,90 |
| Italy | 60.021.955 | 823.000 | 13,71 |
| Colombia | 47.561.000 | 476.506 | 10,01 |
| Brazil | 201.032.714 | 1.769.572 | 8,80 |

Data source: The GVR, April 2014
*United Nation 2013

# NGVs in EUROPE

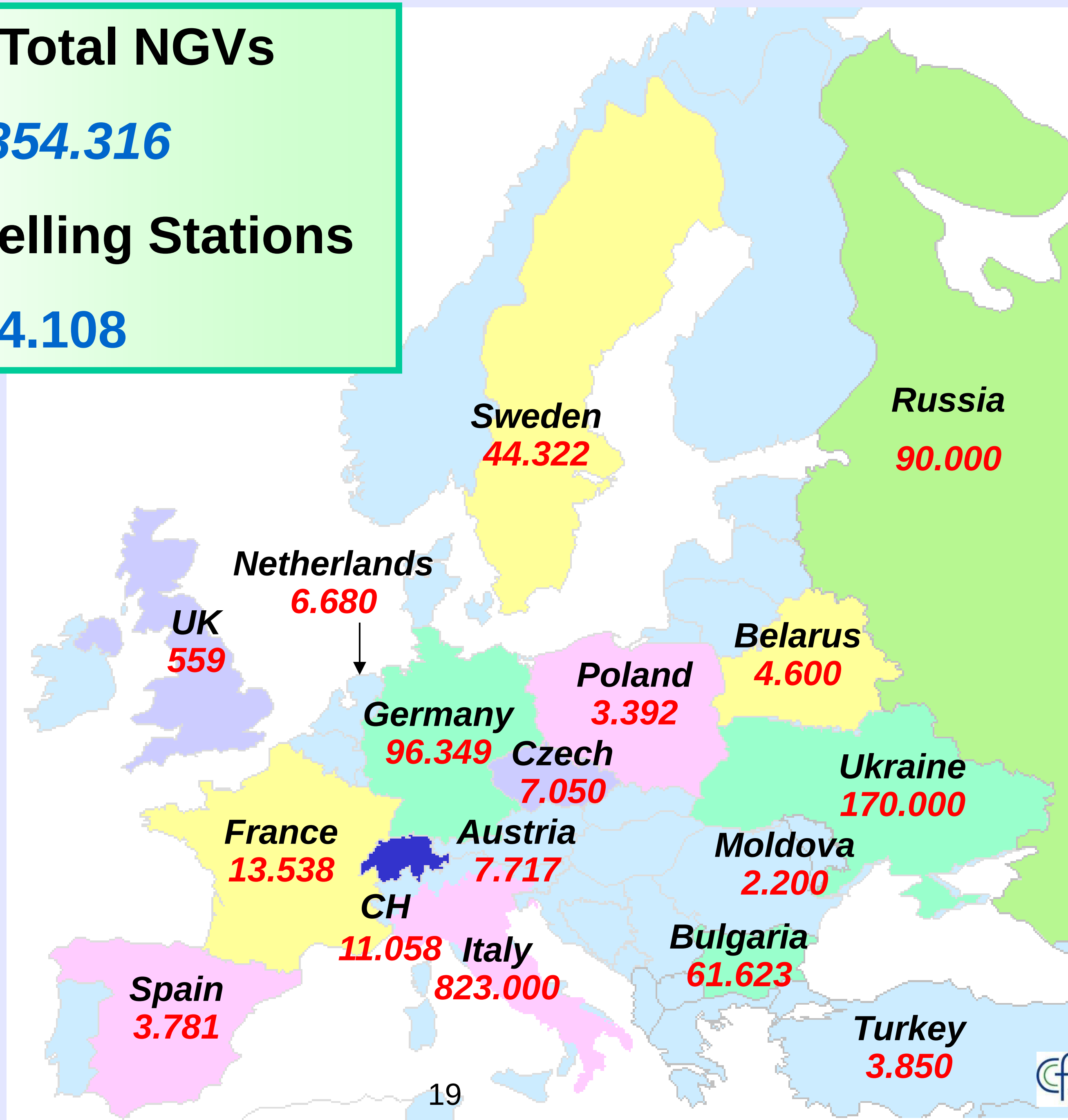
**Europe Total NGVs**

**~1.354.316**

**NGVs Refuelling Stations**

**~ 4.108**

**April 2014**




*** Rounded up figures**

Data source:
The GVR,
April 2014

# Total Fuelling Stations (Public and Private)

**Europe Total NGVs**

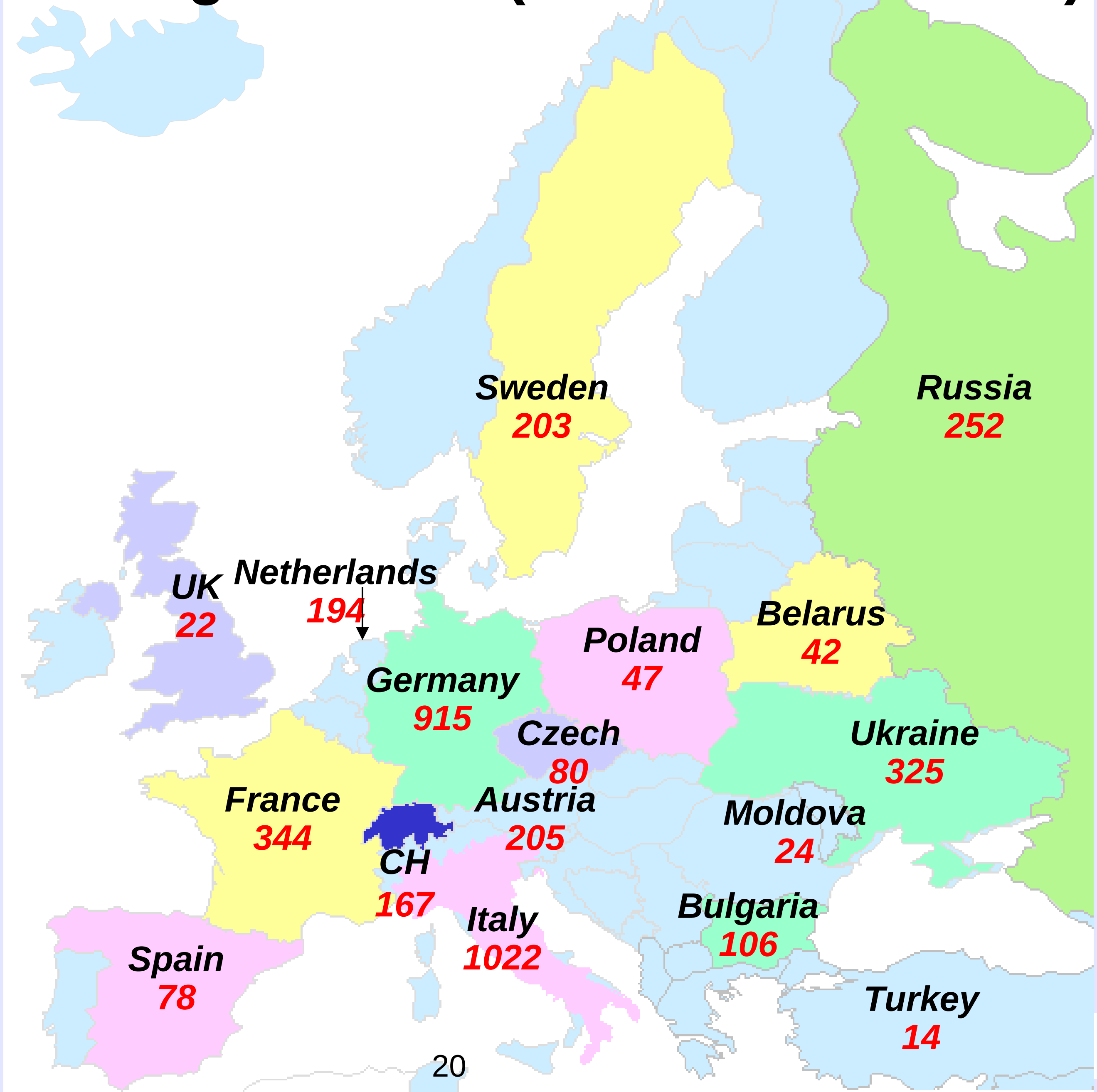
**~ 1.354.316**

**Refuelling Stations**
**~4.108**
**Stations Under Construction**
**292**

## April 2014

*** Rounded up figures**

Data source:
The GVR,
April 2014




FS in EUROPE

# NGV GROWTH RATES 2006-2014

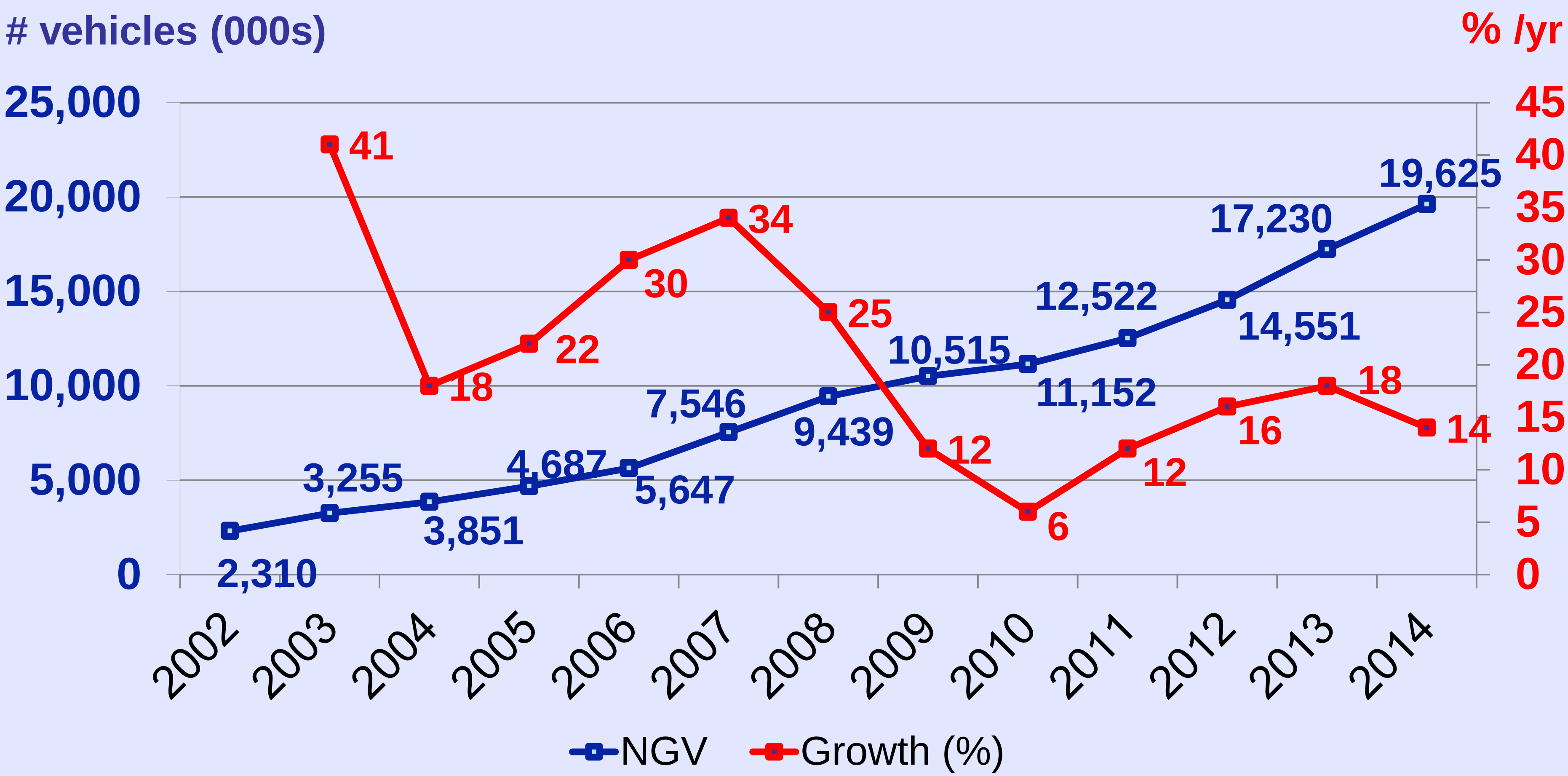
## (April 2014)

| | 2006 | 2014 | % |
|---|---|---|---|
| **WORLD** | **4,6 Million** | **19,6 Million** | **326%** |
| **CHINA** | 97.200 | 3 Million | **2986%** |
| **BRAZIL** | 1 Million | 1,77 Million | **77%** |
| **EUROPE** | 556.000 | 1,35 Million | **143%** |
| **UKRAINE** | 67.000 | 170.000 | **153%** |
| **ITALY** | 382.000 | 823.000 | **115%** |

**Data: The GVR, April 2014**

# World NGV Growth

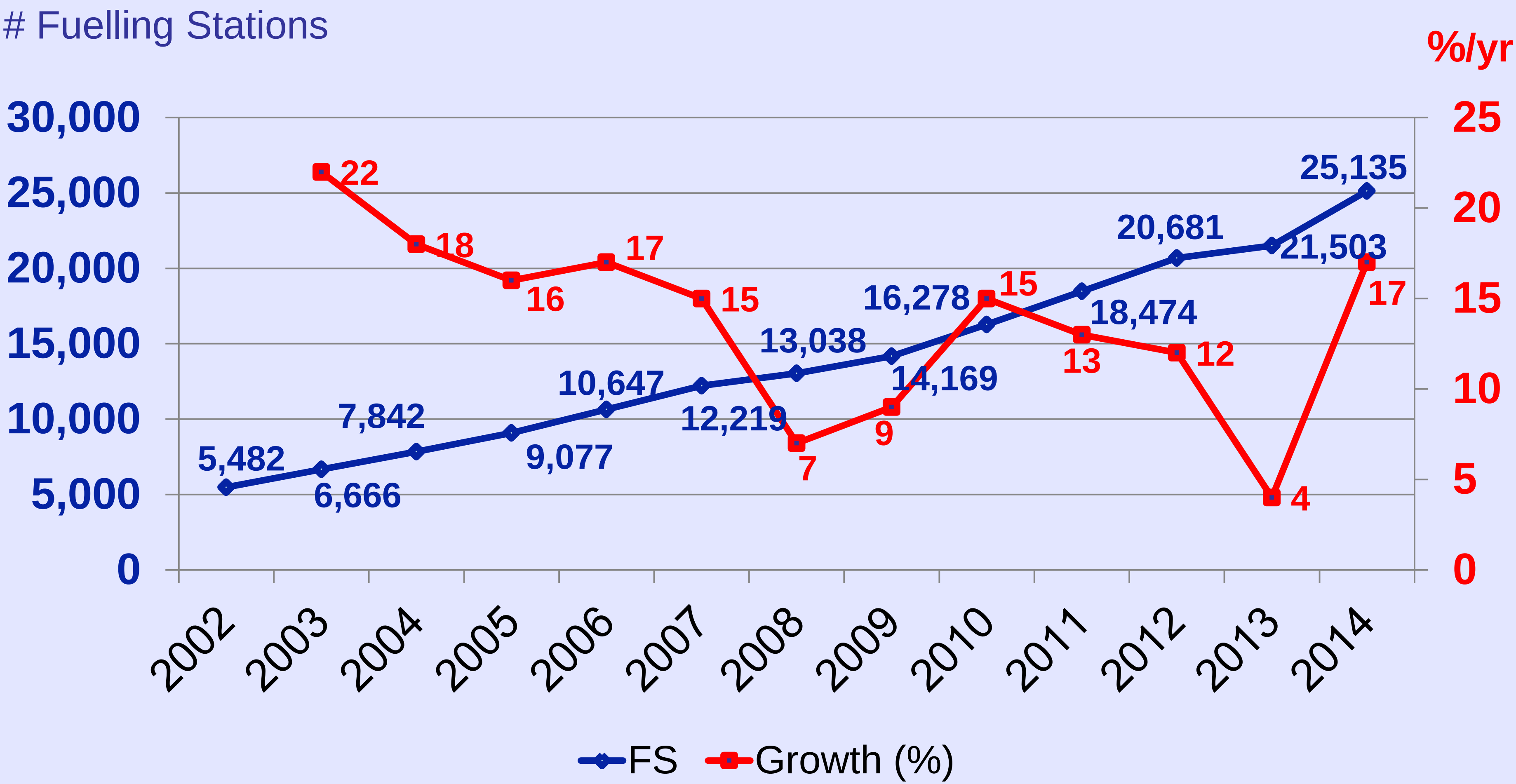
## Vehicle Numbers & % Growth Rate




**Data source: The GVR, April 2014**

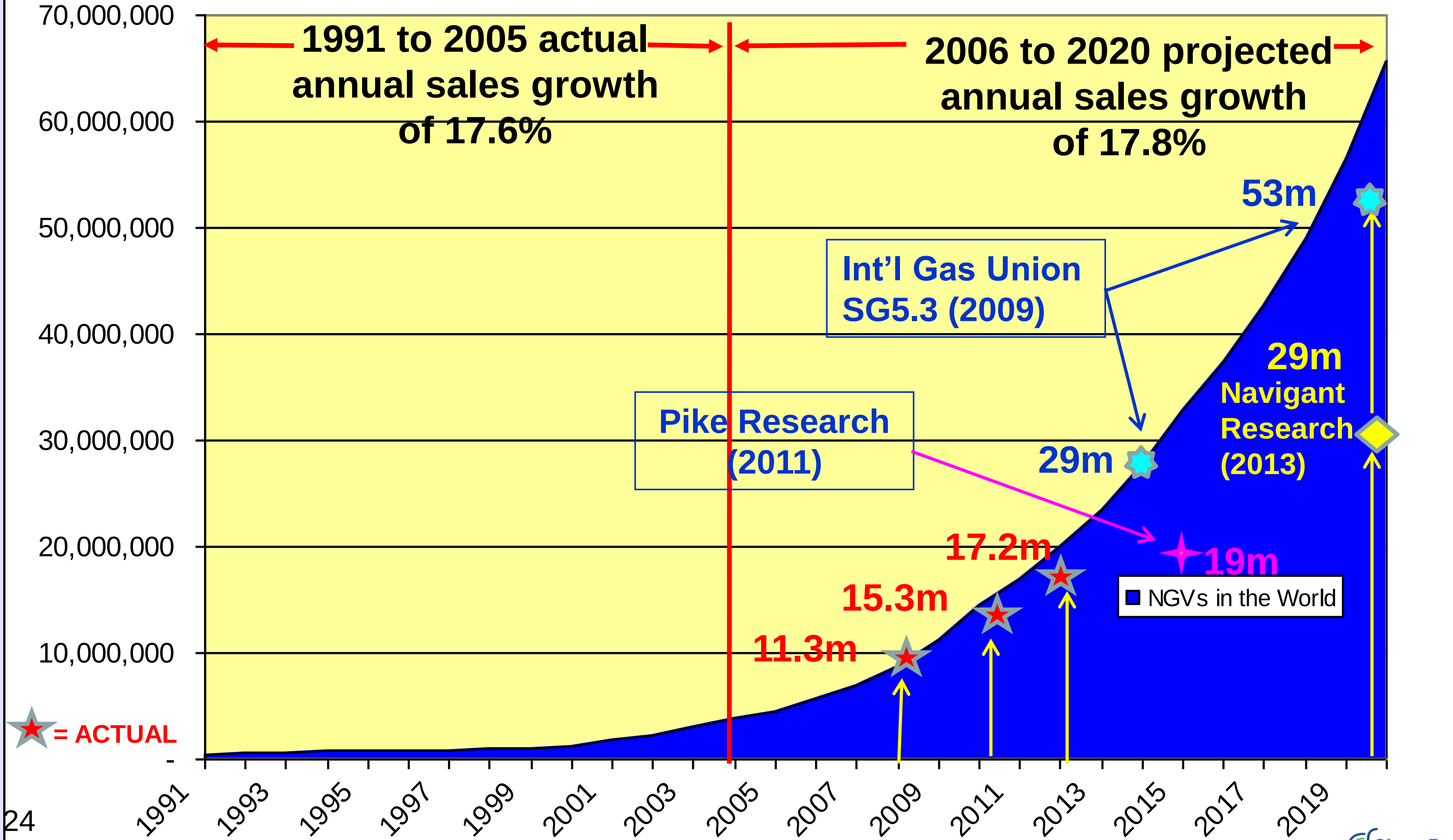
# World Fuelling Station Growth

## Station Numbers & % Growth Rate



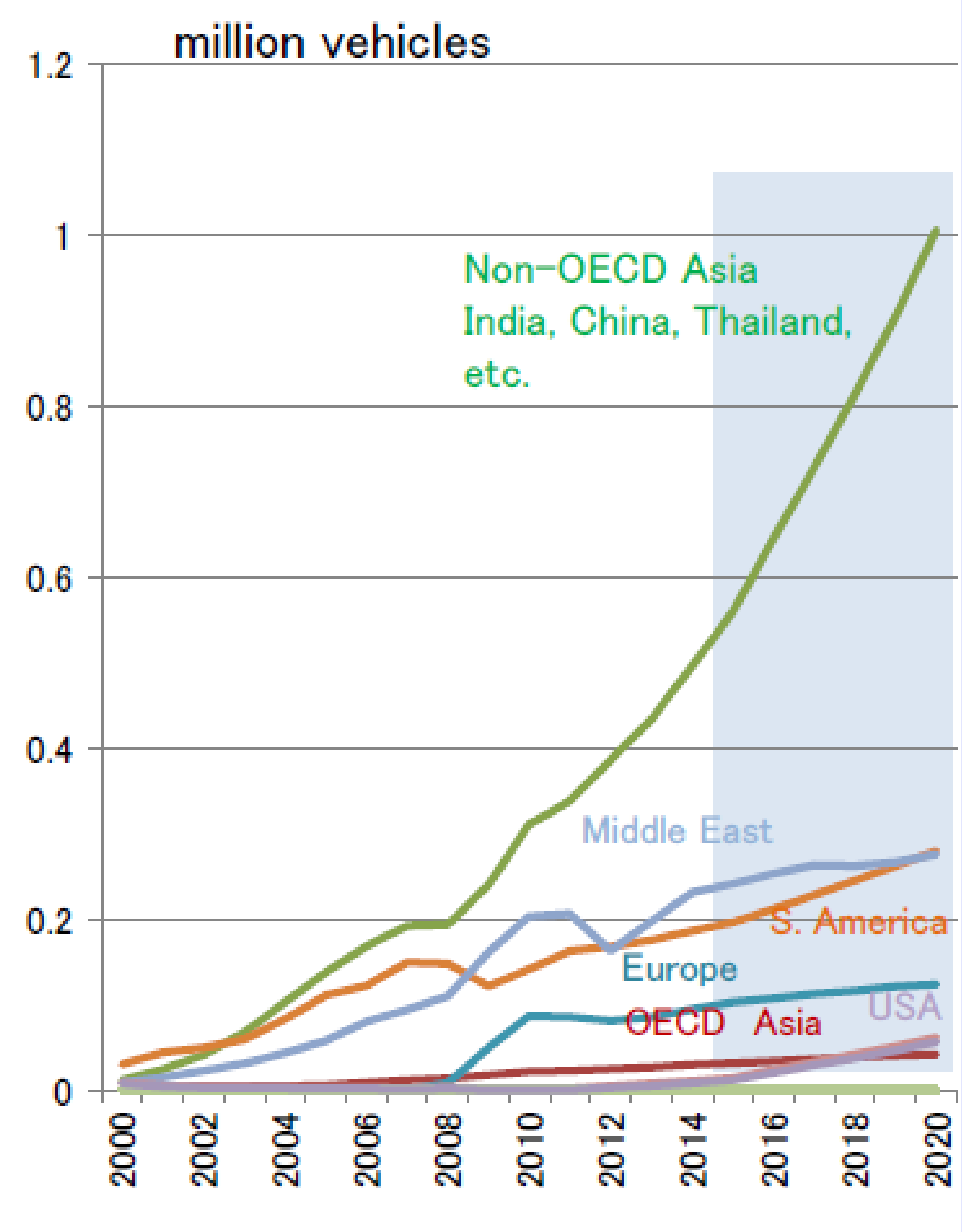

Data source: The GVR, April 2014

# World Wide NGV Growth Actual & Various Projections to 2020



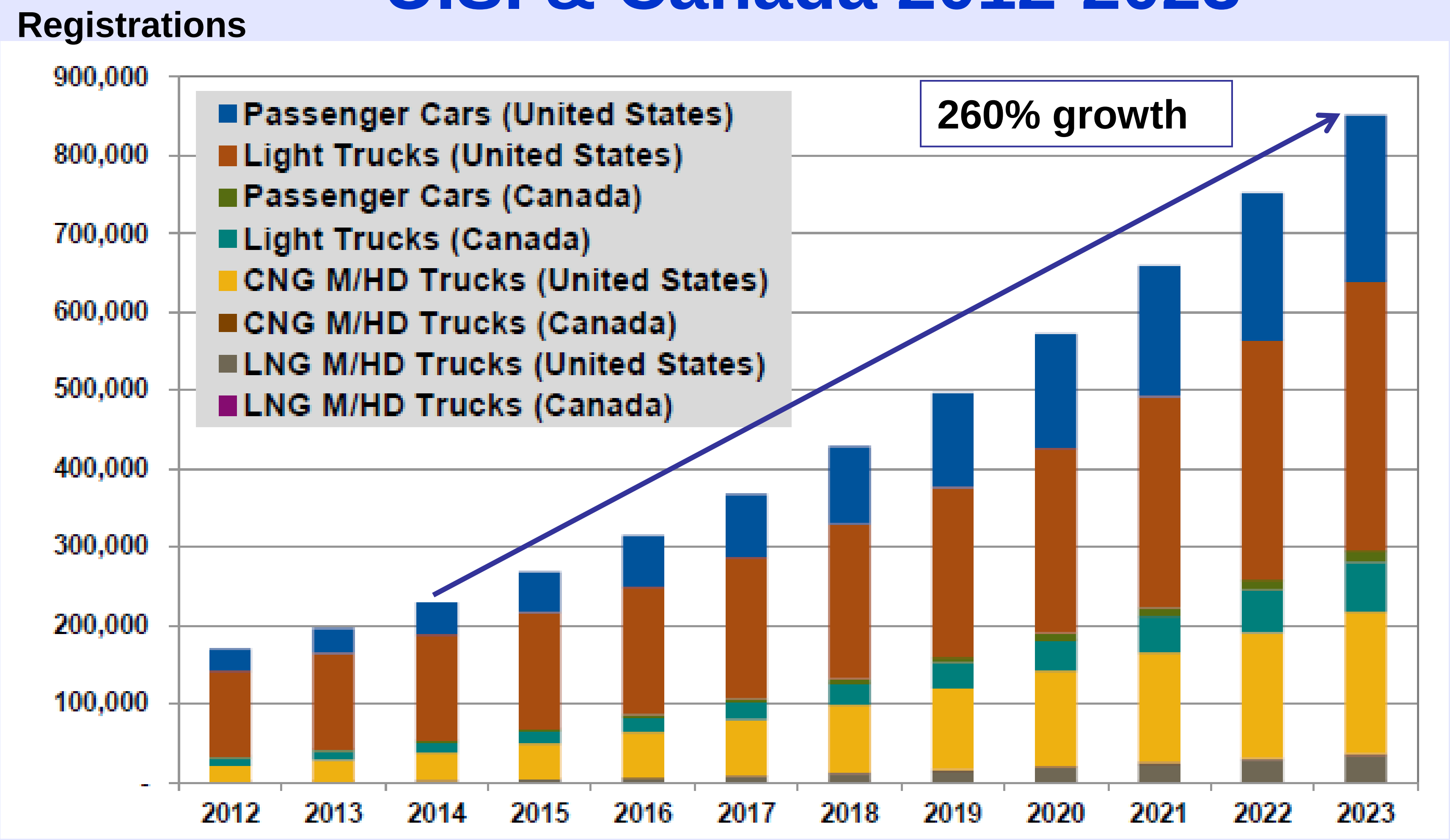

John Lyon, IANGV, 2007 adapted by Clean Fuels Consulting 2013

# Projected global regional ***sales volume*** outlook



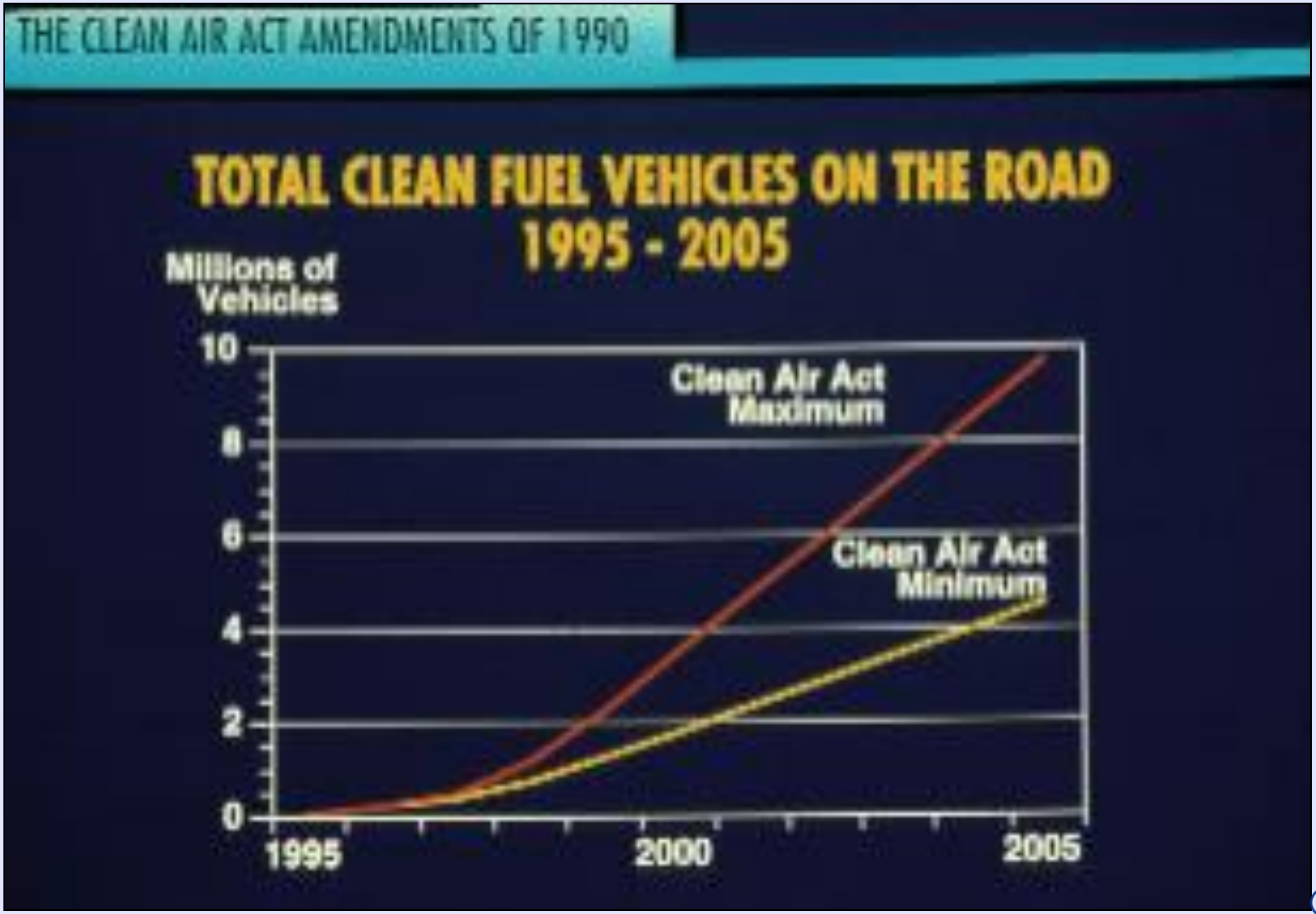

Source: Study on Required CNG Qualities as an Automotive Fuel, M. Matsuki, Honda R&D Co, ANGVA November 2013, based on HIS Cambridge Energy Research Associates.

# Forecast NGV registrations by segment U.S. & Canada 2012-2023



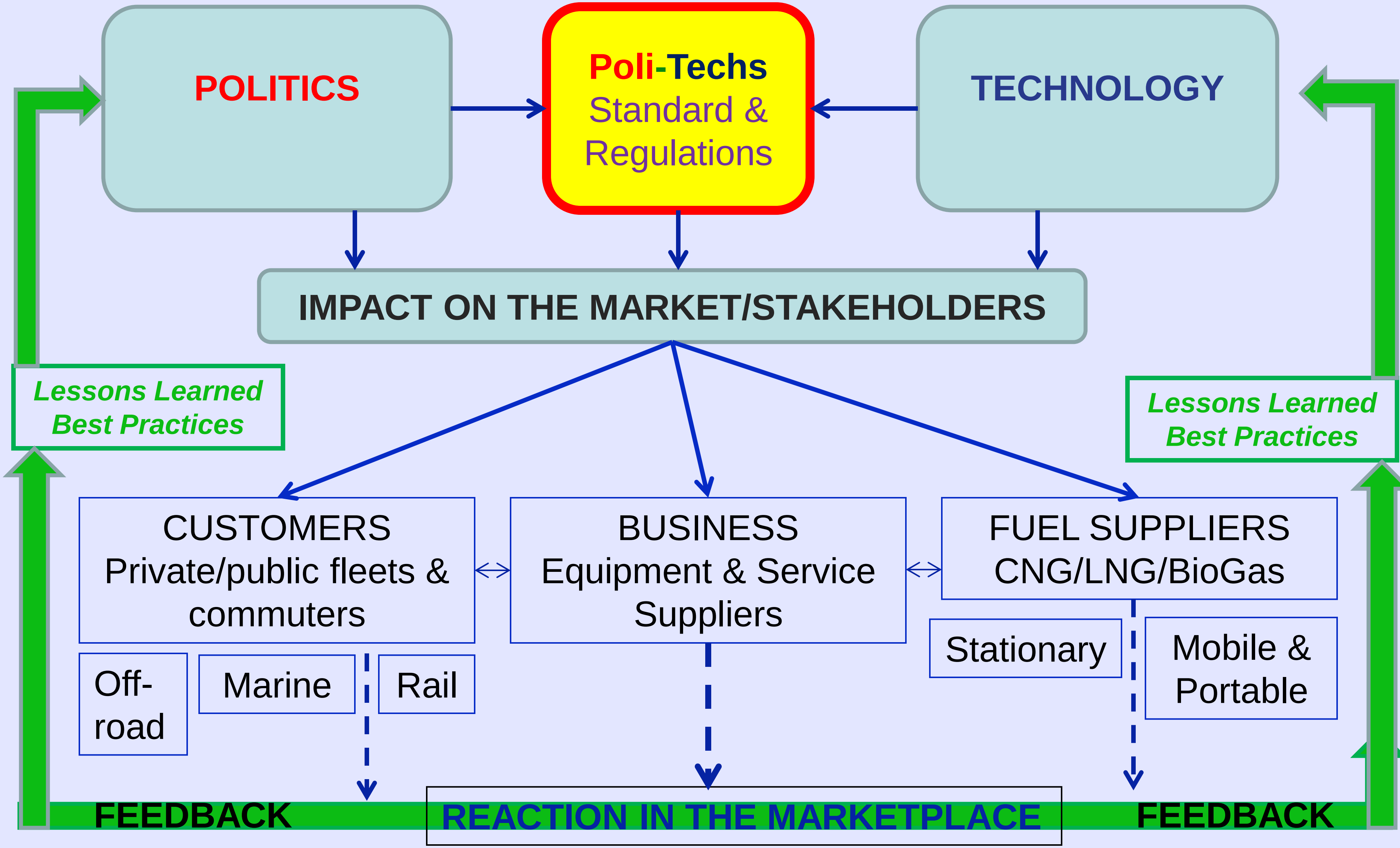

Source: N. American Light Duty Vehicles & Medium/Heavy Duty Truck Forecasts (prepared for the Fuels Institute), Navigant Research ,August 16, 2013.

# How good are projections?
## A U.S. NGV historical perspective… growth based on provisions in the Clean Air Act Amendments of 1990




Source: Gas Research Institute circa 1991

# Structure & Dynamics Framework for this presentation



# Standards & Regulations

- A foundation for commercializing technologies
- Complex international networks
- Harmonization is the end-goal
- To be successful implementation AND *enforcement* are critical

# DEFINITIONS

- **STANDARDS**
  - Not ‘legal’ (i.e. not binding) but are intended to be *defacto* models for codes
  - Performance or prescriptive
- **REGULATIONS (also know as *codes*)**
  - *Dejure*/legal, with enforcement implications
  - Can adopt standards by reference or amendment

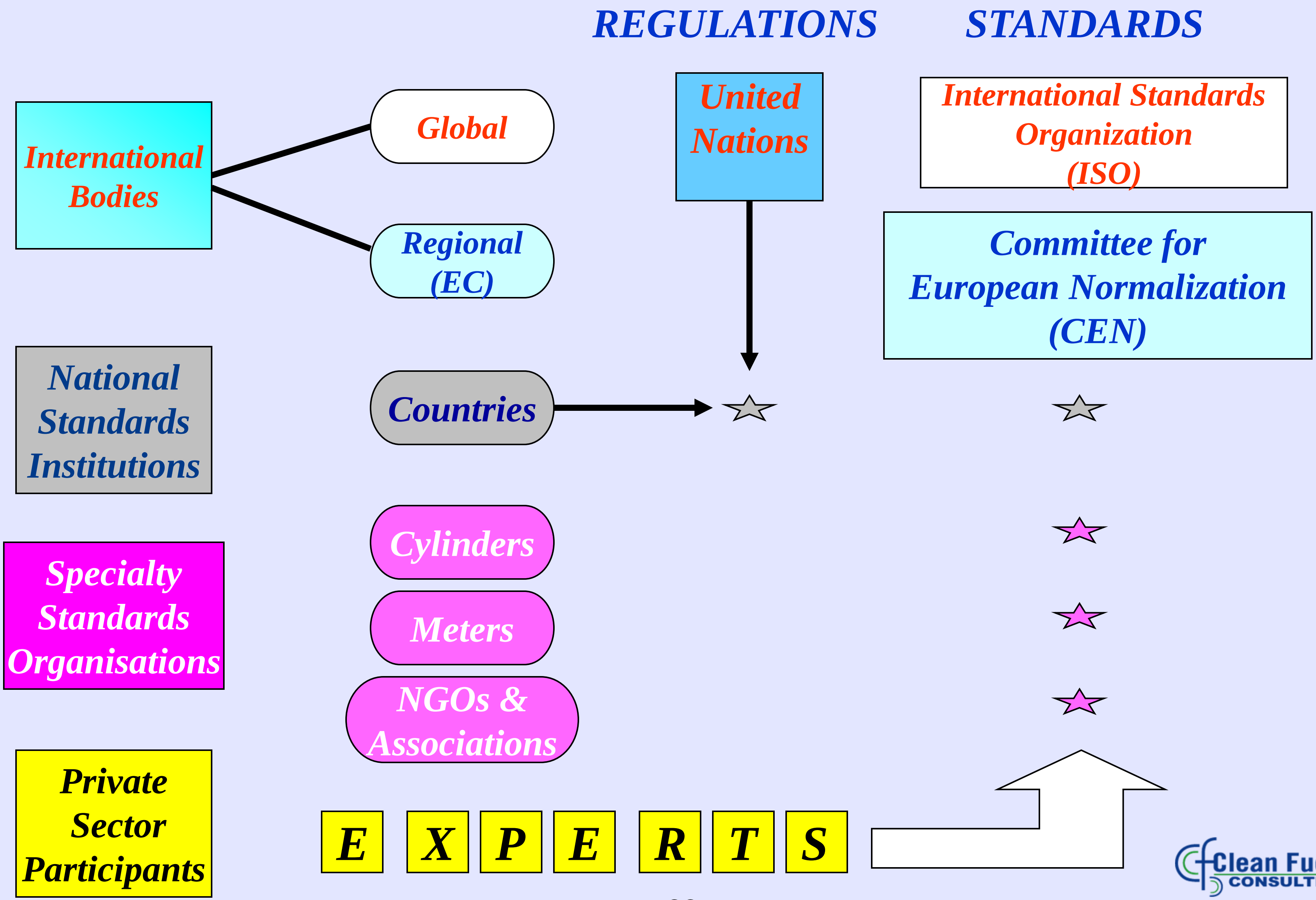
# Critical Need for Standards & Regulations

- Safety of equipment: fabrication & testing
- Reliability of equipment & systems
- Promote best practices
- *Harmonized* standards & regulations foster economic (*not cheap*) critical mass for equipment sold across international markets.
- No regulations – no markets

= ACCOUNTABILITY

= PROFIT

# LEVELS OF STANDARDS & REGULATIONS
## (The Patchwork Quilt)



# UN Structure for Gaseous Fuel Vehicle Regulations

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF:
I. LPG RETROFIT SYSTEMS
II. CNG RETROFIT SYSTEMS

United Nations Economic Commission for Europe (UN / ECE)

WP1 Road Traffic Safety

Road Signage



Inland Transport Committee

Working Party.29
World Forum for Harmonization of Vehicle Regulations

Group of Experts on Pollution and Energy (GRPE)
Regulation 115

Group of Experts on General Safety Provisions (GRSG)
Regulation 110
Regulation 67

SPECIFIC COMPONENTS OF CNG SYSTEMS AND THEIR INSTALLATION ON VEHICLES (R67 IS COROLLARY FOR LPG)

Informal Group Gaseous Fuelled Vehicles

HDDF TF

LNG TF

# UNECE regulation development process can take a *minimum* of 15 months; often longer

**Informal group mandate (chair) CP (technical sponsor)**

**Proposal (new Regulation, or amendment of existing Reg)**

or

**Informal working group develops a proposal**

**Informal Document**

**GRPE**

**Working Document**

**12 weeks**

**½ Year**

**GRPE**

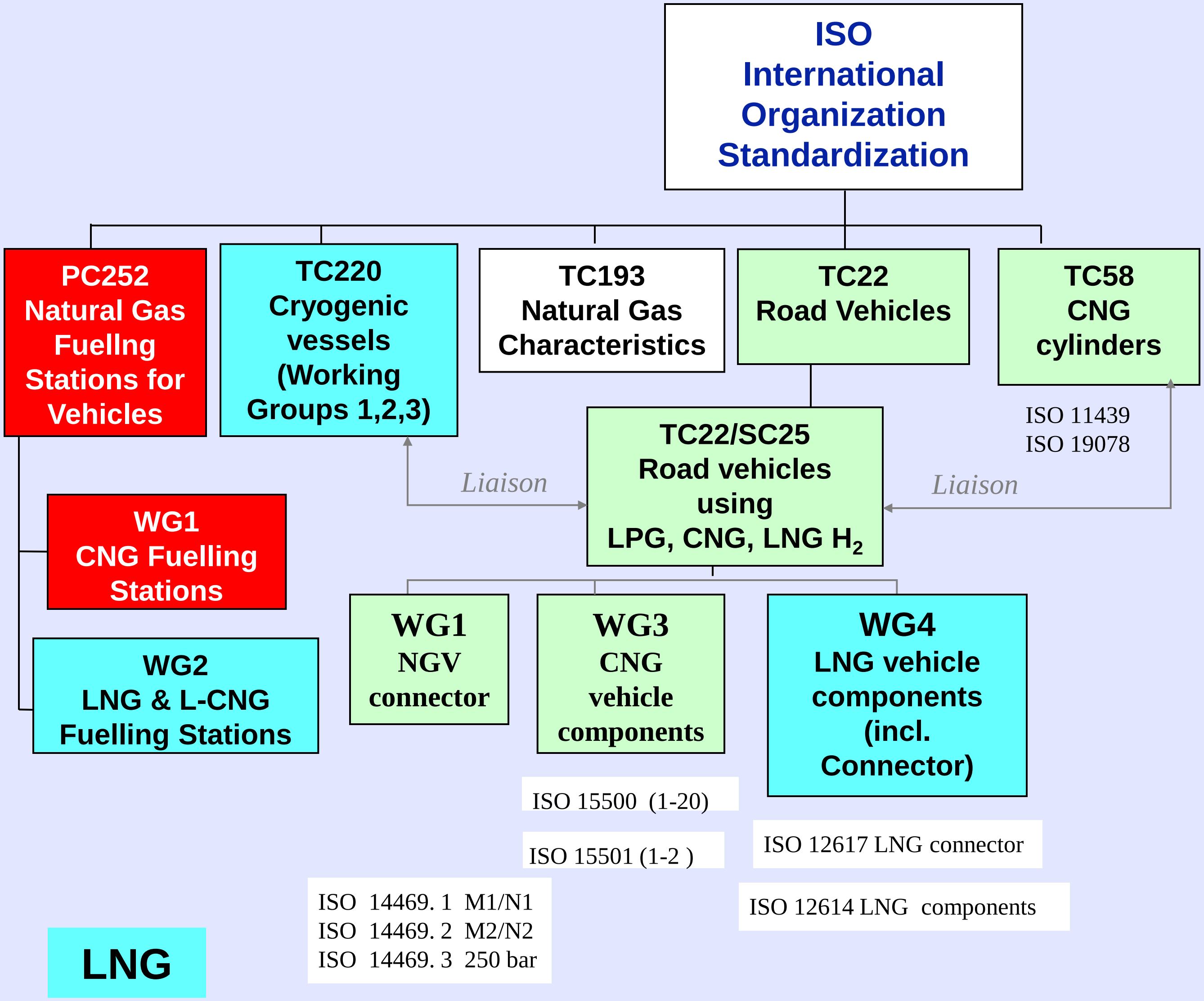
**Approved (WP.29)**

**1/3 Year**

**WP.29**

Enters into force in New York 6-8 months

# ISO STANDARDS FOR NGVs




**ISO took over the responsibility to develop fuelling station standards from CEN.**

**The final 'Draft International Stage' for stations & Vehicular Refuelling Appliances (VRAs) (prEN 13638) is adopted (March 2014) and** should **be finalized shortly.**

**Adapted from:** ***Harmonization of ISO Standards and UN Regulations: New on-board components for CNG, H2 and CNG-H2 blends,*** **A. Bassi, SINTESI , March 2008. Updated November 2012**

# THE *TYPICAL* ISO STANDARDS DEVELOPMENT PROCESS TAKES 3-4 YEARS

**New Work Item Proposed**
**Year 1: March**

**Working Draft Prepared**
**Year 1: June**

(Meetings)

**Committee Draft Prepared**
**Year 2: June**

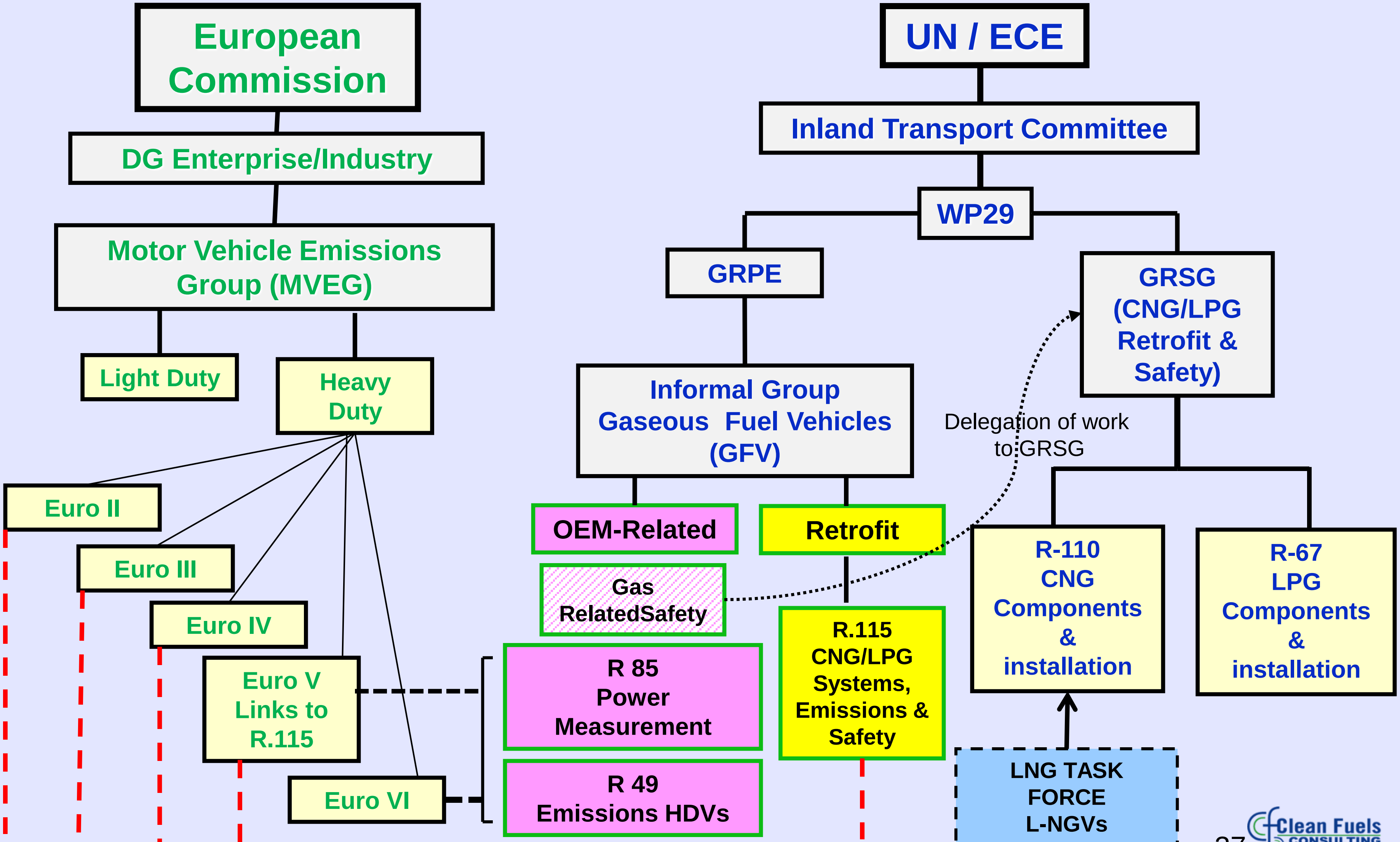
**Draft International Standard (DIS) (Enquiry)**
**Year 3: June**

**Final DIS Approval**
**Year 3: Dec.**

**ISO PUBLISHES STANDARD**
**Year 4: June**

# Regulatory Landscape to Develop Engine & Emissions Certification Regulations

## Heavy Duty Vehicles



# UNECE Regulations for heavy duty LNG trucks and for dual-fuel engines are in place!

- **LNG trucks** amending R.110 (NGV components) come into force by June-July 2014.
- **OEM heavy duty dual-fuel Euro VI** (R.49, Emissions of HD engines) in force as of July 2013;
- **HDDF Euro V** will come into force July 2014.
- **Dual-fuel retrofit** engine regulations are now in development (new regulation).

# Changes in International Maritime Organization (IMO) regulations is the next door opener to the largest potential NGV market of the future


Passenger & Car Ferry

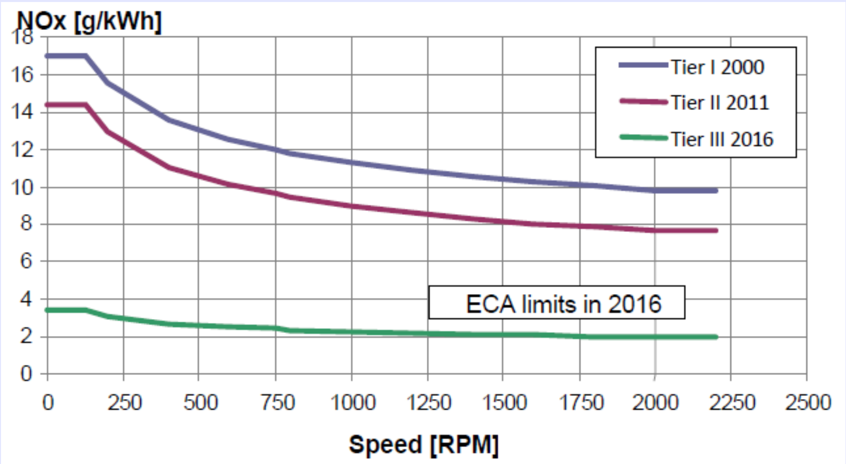
Supply Ship


Coast Guard

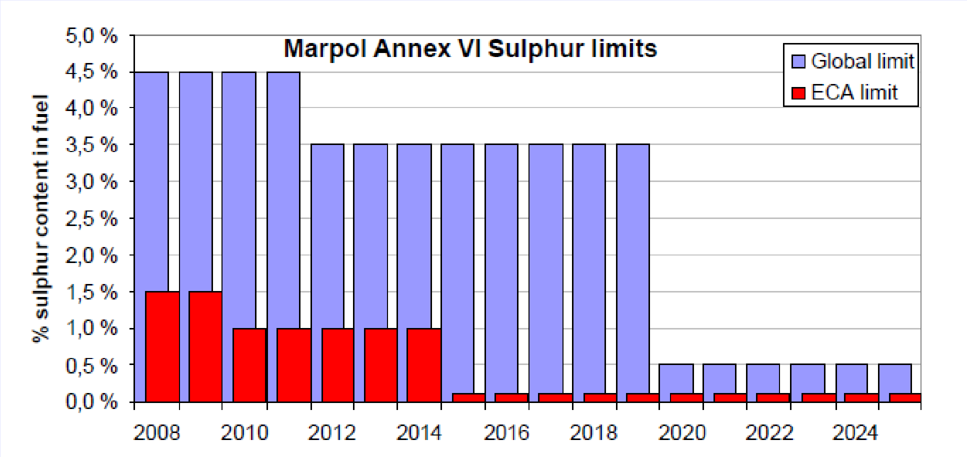
Fjord Ferry

Images by Gasnor 2008, from *LNG as a Ship Fuel*, Creatieve Energie, June 2009

# IMO limits on NOx emissions and sulphur limits in fuel has begun the shift to LNG in the marine sector




NOx emissions reductions from engines



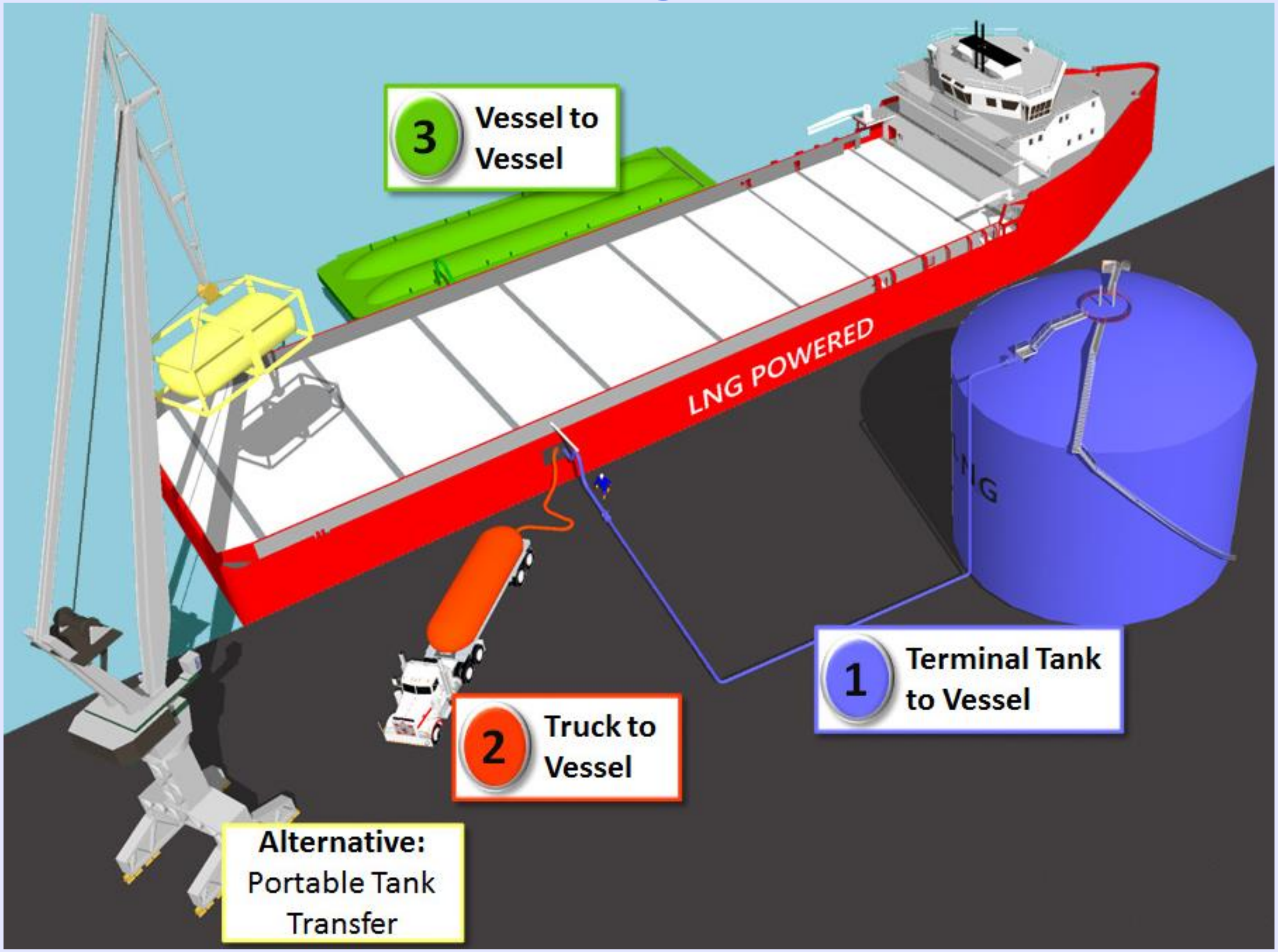

% Sulphur reductions in fuel


New emissions limits and sulphur content limits take effect in U.S. and European Emission Control Areas (ECAs)

Clean Cities U.S. Department of Energy

Clean Fuels CONSULTING

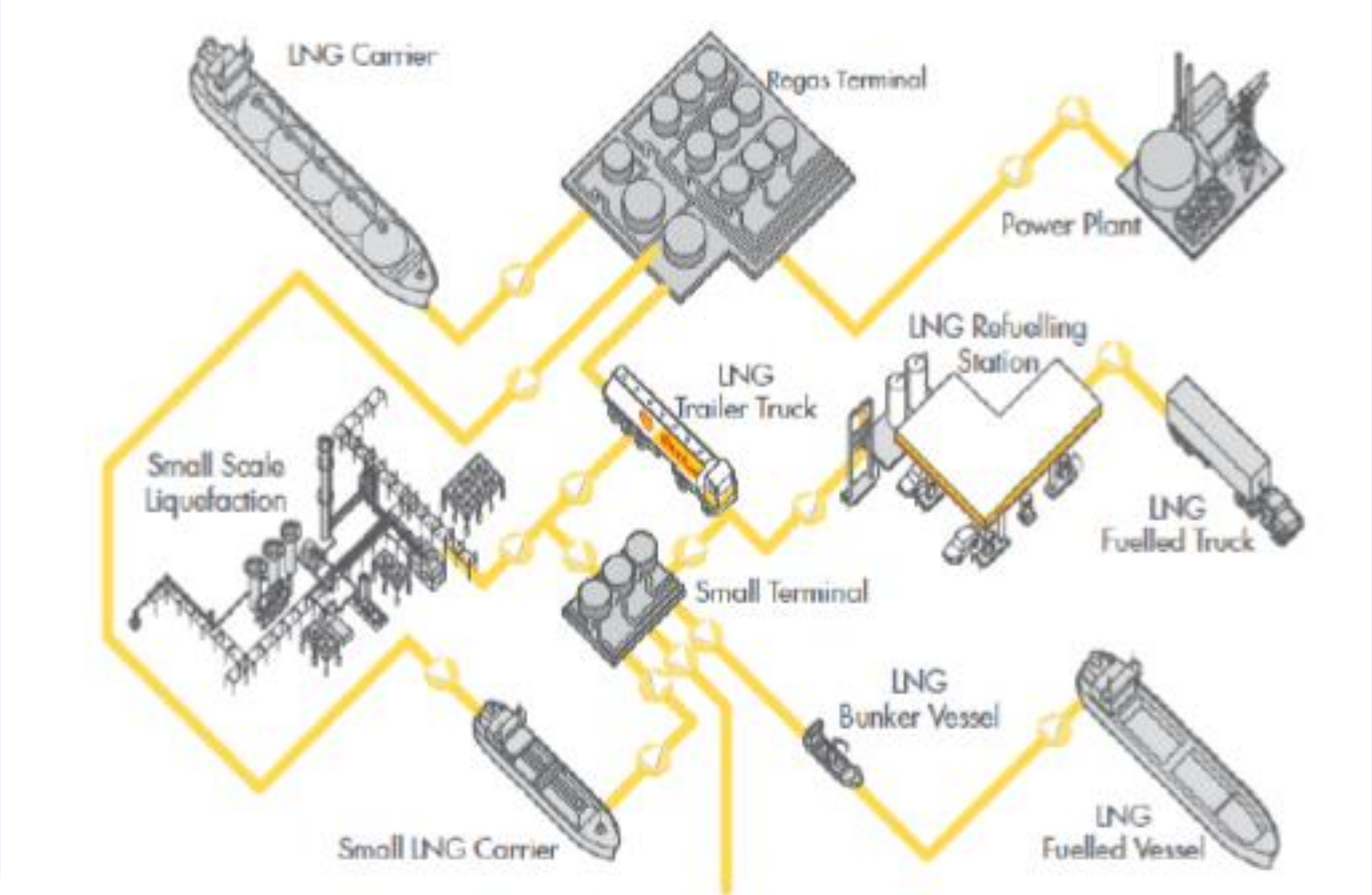
# Various LNG Bunkering Solutions… but standards & regulations are needed




ISO TC28 & TC 67; CEN TC282

Source: Bunkering of Liquefied Natural Gas-fueled Marine Vessels in North America, American Bureau of Shipping, 2014

# LNG for shipping will be good for LNG trucking as fuel supply is integrated between sea and land applications




Source: Royal Dutch Shell plc

# *Safety* continues to be a critical issue for regulators and customers

- "What is known is liked. What is unknown is disliked. Make the unknown known."
- Industry must understand the reasons for failures and fix the problems.
- Scientific studies (i.e. HAZOP, etc.) are needed.
- Videos help educate people
- Training at all levels is critical

# Selected Summary Points

- Alternative fuel source(s) must be pursued on a timely basis as any major transition will take many years.
- Fuel transition(s) must be as few as possible, because the infrastructure change-over expense ~~may~~ will be huge.
- Realignment of ongoing fuel shifts may be necessitated by major changes in:
  - Technology
  - International affairs
  - World pricing and supply of fuels

Source: *Checklist for Transition to New Highway Fuel(s)*, Charles Risch, Danilo Santini, January 2012.

Politics Technology

# Lessons Learned

Marketing Communications

## Create & support NGV associations

- NGV associations have been lightning rods and catalysts for NGV growth
- Associations provide a focus for advocacy work (especially national), market strategy & development and technology advancement.
- Stakeholders need to continue and expand their support of the associations as it elevates the commercialization efforts.

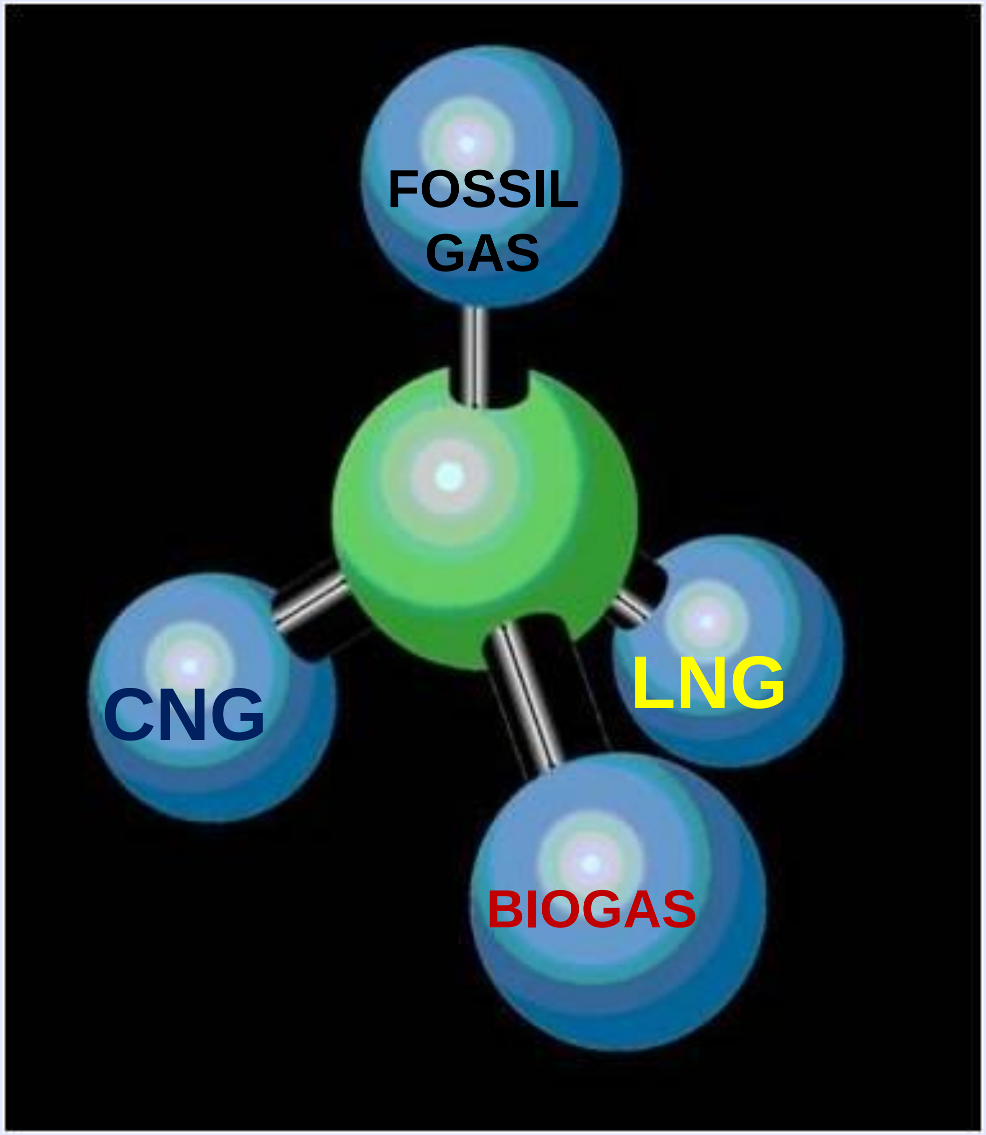
# THERE ARE NO FUEL PANACEAS

- Every fuel has its benefits and its challenges
  - Cost
  - Environmental quality & impacts
  - Energy availability & security
  - Compatible vehicle technologies
- The critical challenge is to find the right balance and mix of fuels in the marketplace
- Petroleum-based vehicle technologies improve but need better quality and more expensive fuels
- Creates new opportunities for alternatives but…
- Status-quo liquids will be around for a long time

Clean Cities
U.S. Department of Energy

Clean Fuels CONSULTING

# METHANE IS A DIVERSE & FLEXIBLE FUEL FOR THE TRANSPORT SECTOR



# Keep your eyes focused on the road ahead and make good policy today that gets us where we want to go!


The future is a big place. It's going to take a long time to get there.

Clean Cities Webinar

# NGVs Past & Prologue

## Lessons Learned to Create Deployment Strategies for Commercializing NGVs:

## Global Overview of Markets & Poli-techs (standards & regulations)

presented by


**Dr. Jeffrey Seisler**

Clean Fuels Consulting


6 October 2014

U.S. Department of Energy